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Carbon Dioxide Equivalent Carbon Stock under Wheat and Eucalyptus Based Agroforestry System in Central India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was organised to evaluation of carbon dioxide equivalent carbon stock or sequestration by wheat, weed and eucalyptus tree under an agroforestry system with different weed control treatments. The two year experiment was performed during 2016-17 and 2017-18 in a well managed farmer field of block shahpura village majitha, Jabalpur with supervision of department of forestry jnkvv Jabalpur. The result revealed that the wheat crop found total CO_2 equivalent C stock was significantly higher under hand weeding at 30 DAS 15.62 and 14.07 t/ha during 2016-17 and 2017-18, respectivelyover weedy check.The pooled data in wheat crop showed thatweed management practices was found higher total CO_2 equivalent C stock range from (10.87 to 14.85 t/ha) over weedy check (9.68 t/ha) under wheat-*Eucalyptus tereticornis* based agroforestry system.The total CO_2 equivalent C stockin weed was significantly higher under weedy check (4.31 to 4.37 t/ha during 2016-17 and 2017-18, respectively) over hand weeding at 30 DAS (0.57 and 0.18 t/ha during both year). The pooled data showed that the average total CO_2 equivalent C stock in weed was significantly higher under weedy check (4.34 t/ha) over hand weeding 30 DAS (0.30

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t/ha). The weed management practices was found lower CO_2 equivalent C stockrange from (0.38 to 1.80 t/ha) under a wheat-*Eucalyptus tereticornis* based agroforestry system. The total CO_2 equivalent C stock of eucalyptus tree was found range between 195.11 to 204.61 t/ha and 248.39 to 258.78 t/ha was found during during 2016-17 and 2017-18, respectively under wheat-*Eucalyptus tereticornis* based agroforestry system.The statistical analysis of the pooled data showed that the CO_2 equivalent C stockin eucalyptus tree varied from 224.18 to 230.86 t/ha was found under wheat-*Eucalyptus tereticornis* based agroforestry system.CO_2 equivalent C stockof agroforestry system was found to range between 63.06 to 66.93 t/ha and 62.48 to 66.01 t/ha during 2016-17 and 2017-18 under wheat-*Eucalyptus tereticornis* based agroforestry system.The pooled data showed that total CO_2 equivalent C stockin agroforestry system was found varied from 62.77 to 66.47 t/ha under wheat-*Eucalyptus tereticornis* based agroforestry system.

Keywords: Carbon stock; wheat; weeds; eucalyptus; carbon dioxide.

1. INTRODUCTION

The increasing atmospheric carbon dioxide is one of the important reasons to increase global warming. Every single element of the earth has capacity to store and release carbon in the earth. In the terrestrial ecosystem each component such as tree, crop and other vegetation have capacity to store atmospheric carbon through photosynthesis and other processes. The agrofoestry system consist of three component such as tree crop and animal. These component play important role to store atmohpheric carbon and released it. The Eucalyptus tree is being exceedingly accepted by farmers due to its fast growth and short rotation or maturity period and various uses by industries. The crop are growing under a tree canopy is increase the overall productivity of land area and reduce the risk of failure of one crop. Wheat is growing in different region for food purpose and it is one of the income sources of the farmers under crop cultivation. For cumulative increasing the productivity of wheat crop, the management practices such as weed management, insect pest management is essential practices adopted by farmers. Here the experiment was conducted to know about the how much tree crop and weeds, the agroforestry vegetation are store carbon dioxide equivalent carbon stock under wheat and *Eucalyptus tereticornis* based agroforestry system with different weed management practices.

2. MATERIALS AND METHODS

The experiment was conducted at farmer field of block shahpura village majitha, Jabalpur with supervision of department of forestry Jnkvv Jabalpur during 2016-17 and 2017-18 with 4 and 5 year old Eucalyptus tereticornistreespacing of 3x1.5 m understory with wheat cropin agroforestry system and also apllied with different weed control treatments. The randomized block design with three replications, consisted of ten weed control treatment [2, 4-D @ 0.5 lit /ha, Metribuzin @ 0.250 Kg /ha, Butachlor @1 lit /ha, Clodinafop-propargyl @0.140 kg /ha, 2, 4-D@ 0.5 lit /ha *fb* metribuzin @0.250 Kg /ha, 2, 4-D @0.5 lit /ha *fb* Butachlor @1 lit /ha, Metribuzin@ 0.250 Kg /ha *fb* butachlor @1 lit /ha, 2, 4-D@ 0.5 lit /ha + hand weeding 30 DAS, Hand weeding 30 DAS and Weedy check] was used in experiment. Variety LOK-1 Wheat was sown with 25 cm row spacing at a depth of 4 cm from the top of the soil. The herbicides were applied as post emergent at crop tillering stage i.e. about 30 DAS.

2.1 Data Collection and Analysis

This study was undertaken to find out an agroforestry system total carbon stock, all material sample was collected from experimental field and convert into dry matter content and convert into dry biomass per hectare and dry biomass was converted into carbon by ash method. To determine carbon dioxide sequestration potential or equivalent carbon stock by trees, crops and weeds the biomass carbon stock was multiplied 3.67factorfor all species by the formula suggested by Rajput [1]. Factor 3.67 were found by the carbon and oxygen molecule atomic weight ratio such as CO_2have one molecule of carbon and 2 molecules of oxygen.

The Carbonatomic weight is 12 and Oxygenatomic weight of is 15.9 so the total atomic weight of carbon dioxide is 43.9 [C(12) + 2 O (15.9+15.9) = 43.9) and the ratio of CO_2 to C is 43.9/12 = 3.67.

Carbon dioxide equivalent Carbon stock = carbon Stock x 3.67

3. RESULTS AND DISCUSSION

The carbon pool of crops and trees were converted into carbon dioxide equivalent C stock, the significant variation was observed under agroforestry system for carbon dioxide sequestration potential.

3.1 Carbon Dioxide Equivalent C Stock by Wheat

The significantly maximum aboveground CO_2 equivalent C stockof wheat crop (Table 1) was noticed under hand weeding at 30 DAS (12.56 and 11.32 t/ha) over weedy check during both the year. The different weed control treatments show higher CO_2 equivalent carbon stock varied from (9.31 to 11.21 t/ha) during first year and (8.19 to 9.98 t/ha) during second year. The statistical analysis of the pooled data also reported the same pattern of aboveground CO_2 equivalent C stockunder wheat-*Eucalyptus tereticornis* based agroforestry system. The belowground CO_2 equivalent C stockwas significantly higher under hand weeding at 30 DAS (3.06 and 2.75 t/ha) during both the year. The total CO_2 equivalent C stockwas significantly higher under hand weeding at 30 DAS (15.62 and 14.07 t/ha) over weedy check during both the year. The statistical analysis of the pooled data reported that the average CO_2 equivalent C stockof wheat crop was significantly higher under hand weeding at 30 DAS (14.85 t/ha) over weedy check (9.68 t/ha). The weed management practices was found higher total CO_2 equivalent C stockrange from (10.87 to 13.16 t/ha) over weedy check (9.68 t/ha) under wheat-*Eucalyptus tereticornis* based agroforestry system. The higher above and belowground CO_2 equivalent C stockwas noticed under weedy check plot because the higher growth and biomass production was found under this treatment. Thevathasan and Gorden [2] also concluded that, the annual CO_2 equivalent carbon stock in a hybrid poplar intercropping field was four times higher as compared to sole agriculture cropping fields. Higher CO_2 equivalent carbon stock in intercropping system compared to sole cropping system has supported in case of Pauownia+winter wheat [3] and poplar based system [4].

3.2 Carbon Dioxide Equivalent C Stock Weeds Biomass

Aboveground CO_2 Equivalent C Stock (t/ha): The significantly higher aboveground CO_2 equivalent C stockwas noticed under weedy check (3.48 and 3.55 t/ha during 2016-17 and 2017-18, respectively) over hand weeding at 30 DAS (0.46 and 0.15 t/ha during 2016-17 and 2017-18, respectively).The pooled data showed that aboveground CO_2 equivalent C stock in weeds was significantly higher under weedy check (3.52 t/ha) over hand weeding at 30 DAS (0.31 t/ha) under wheat-*Eucalyptus tereticornis* based agroforestry system (Table 2).

Belowground CO_2 Equivalent C Stock (t/ha): The belowground CO_2 equivalent C stockwas significantly higher under weedy check (0.83 and 0.82 t/ha during 2016-17 and 2017-18, respectively) over hand weeding 30 DAS (0.11 and 0.04 t/ha during 2016-17 and 2017-18, respectively).The pooled analyzed data of belowground CO_2 equivalent C stockin weed was significantly lower under hand weeding at 30 DAS (0.07 t /ha) over weedy check (0.83 t/ha) (Table 2).

Total CO_2 Equivalent C Stockby Weed (t/ha): The total CO_2 equivalent C stockin weed was significantly higher under weedy check (4.31 to 4.37 t/ha during 2016-17 and 2017-18, respectively) over hand weeding at 30 DAS (0.57 and 0.18 t/ha during 2016-17 and 2017-18, respectively).The pooled data showed that the average total CO_2 equivalent C stock **in** weed was significantly higher under weedy check (4.34 t/ha) over hand weeding 30 DAS (0.30 t/ha). The weed management practices was found lower CO_2 equivalent C stockrange from (0.38 to 1.80 t/ha) over weedy check under wheat-*Eucalyptus tereticornis* based agroforestry system (Table 2).

3.3 Carbon Dioxide Equivalent C Stock from Eucalyptus Tree Biomass (t/ha)

3.3.1 Aboveground CO_2 equivalent C stock (t/ha)

The aboveground CO_2 equivalent C stockin eucalyptus tree was increased with increasing age. During first year at the age of 4th year the aboveground CO_2 equivalent C stockin eucalyptus tree range between 161.95 to 154.68 t/ha was found and at the age of 5th year During second year of experiment aboveground CO_2 equivalent C stock of eucalyptus tree was ranged from 197.86 to 209.70 t/ha was found under wheat-*Eucalyptus tereticornis* based agroforestry system.

The pooled data showed that the average aboveground carbon sequestration potential of eucalyptus tree varied from 178.24 to 185.01 t/ha was found under agroforestry system (Table 3).

Table 1. Carbon dioxide equivalent C stock of wheat crop under- *Eucalyptus tereticornis* based agroforestry systems

Treatment	CO_2 equivalent C stock (t/ha)								
	Aboveground			Belowground			Total		
	2016-17	2017-18	pooled	2016-17	2017-18	pooled	2016-17	2017-18	pooled
T_1 - 2, 4-D @ 0.5 lit/ha	10.78	9.11	9.94	2.62	2.20	2.41	13.40	11.32	12.36
T_2- Metribuzin @ 0.250 Kg /ha	10.84	9.30	10.07	2.63	2.25	2.44	13.47	11.55	12.51
T_3- Butachlor @ 1 lit/ha	9.31	8.20	8.75	2.27	1.98	2.12	11.57	10.18	10.87
T_4- Clodinafop-propargyl @ 0.140 kg /ha	11.21	9.98	10.60	2.73	2.41	2.57	13.94	12.39	13.16
T_5 - 2, 4-D @ 0.5 lit/ha *fb* metribuzin @ 0.250 Kg /ha	10.31	9.36	9.84	2.51	2.26	2.39	12.82	11.62	12.22
T_6- 2, 4-D @ 0.5 lit/ha*fb* butachlor @ 1 lit/ha	10.00	9.01	9.51	2.45	2.19	2.32	12.44	11.21	11.82
T_7- Metribuzin @ 0.250 Kg /ha *fb* butachlor @ 1 lit/ha	9.72	8.19	8.96	2.37	2.00	2.19	12.10	10.18	11.14
T_8- 2, 4-D @ 0.5 lit/ha + hand weeding at 30 DAS	10.64	9.22	9.93	2.59	2.24	2.42	13.24	11.46	12.35
T_9 - Hand Weeding at 30 DAS	12.56	11.32	11.94	3.06	2.75	2.91	15.62	14.07	14.85
T_{10}- Weedy check	8.66	6.90	7.78	2.13	1.66	1.90	10.79	8.56	9.68
SEm±	0.22	0.44	0.24	0.05	0.11	0.06	0.27	0.55	0.30
CD (P=0.05)	0.64	1.30	0.69	0.15	0.32	0.17	0.79	1.61	0.86

Table 2. Carbon dioxide equivalent C stock potential of weeds under- *Eucalyptus tereticornis* based agroforestry systems

Treatment	CO_2 equivalent C stock (t/ha)								
	Aboveground			Belowground			Total		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T_1 - 2, 4-D @ 0.5 lit/ha	0.86	0.77	0.81	0.21	0.18	0.20	1.07	0.95	1.01
T_2- Metribuzin @ 0.250 Kg /ha	1.17	0.89	1.03	0.28	0.21	0.25	1.46	1.10	1.28
T_3- Butachlor @ 1 lit/ha	1.64	1.23	1.44	0.39	0.29	0.34	2.03	1.52	1.77
T_4- Clodinafop-propargyl @ 0.140 kg /ha	1.65	1.26	1.46	0.40	0.30	0.35	2.05	1.56	1.80
T_5 - 2, 4-D @ 0.5 lit/ha *fb* metribuzin @ 0.250 Kg /ha	0.79	0.70	0.75	0.19	0.16	0.18	0.99	0.86	0.92
T_6- 2, 4-D @ 0.5 lit/ha*fb* butachlor @ 1 lit/ha	1.37	1.04	1.20	0.33	0.25	0.29	1.70	1.28	1.49
T_7- Metribuzin @ 0.250 Kg /ha *fb* butachlor @ 1 lit/ha	1.64	1.32	1.48	0.39	0.31	0.35	2.03	1.63	1.83
T_8- 2, 4-D @ 0.5 lit/ha + hand weeding at 30 DAS	0.86	0.79	0.83	0.21	0.18	0.20	1.07	0.98	1.02
T_9- Hand Weeding at 30 DAS	0.46	0.15	0.31	0.11	0.04	0.07	0.57	0.18	0.38
T_{10}- Weedy check	3.48	3.55	3.52	0.83	0.82	0.83	4.31	4.37	4.34
SEm±	0.15	0.12	0.10	0.04	0.03	0.02	0.19	0.15	0.12
CD (P=0.05)	0.44	0.36	0.27	0.10	0.08	0.06	0.54	0.43	0.33

Table 3. Carbon dioxide equivalent C stock in eucalyptus tree under- *Eucalyptus tereticornis* based agroforestry systems

Treatment	CO_2 equivalent C stock (t/ha)								
	Aboveground			Belowground			Total		
	2016-17	2017-18	pooled	2016-17	2017-18	pooled	2016-17	2017-18	pooled
T_1- 2, 4-D @ 0.5 lit/ha	154.68	206.31	180.49	40.44	50.74	45.59	195.11	257.05	226.08
T_2- Metribuzin @ 0.250 Kg /ha	157.58	212.44	185.01	41.21	52.08	46.64	198.79	264.52	231.65
T_3- Butachlor @ 1 lit/ha	156.68	202.46	179.57	41.16	51.47	46.31	197.84	253.93	225.88
T_4- Clodinafop-propargyl @ 0.140 kg /ha	156.26	200.23	178.24	40.94	50.94	45.94	197.20	251.17	224.18
T_5 - 2, 4-D @ 0.5 lit/ha *fb* metribuzin @ 0.250 Kg /ha	158.49	202.79	180.64	41.56	52.74	47.15	200.05	255.53	227.79
T_6- 2, 4-D @ 0.5 lit/ha*fb* butachlor @ 1 lit/ha	161.54	201.49	181.51	42.41	51.37	46.89	203.95	252.86	228.40
T_7- Metribuzin @ 0.250 Kg /ha *fb* butachlor @ 1 lit/ha	157.13	209.70	183.42	40.99	52.02	46.51	198.12	261.73	229.92
T_8- 2, 4-D @ 0.5 lit/ha + hand weeding at 30 DAS	157.31	202.72	180.02	41.17	49.23	45.20	198.48	251.95	225.22
T_9 - Hand Weeding at 30 DAS	160.71	207.69	184.20	42.22	51.10	46.66	202.94	258.78	230.86
T_{10}- Weedy check	161.95	197.86	179.91	42.66	50.54	46.60	204.61	248.39	226.50
SEm±	3.89	4.15	2.81	1.09	1.25	0.82	4.98	5.02	3.49
CD (P=0.05)	11.37	12.12	7.98	3.19	3.65	2.32	14.54	14.64	9.91

Table 4. Carbon dioxide equivalent C stock in wheat, weeds and eucalyptus tree under agroforestry system

Treatment	CO_2 equivalent C stock from agroforestry system (t/ha)								
	Aboveground			Belowground			Total		
	2016-17	2017-18	Pooled	2016-17	2017-18	pooled	2016-17	2017-18	Pooled
T_1 - 2, 4-D @ 0.5 lit/ha	50.30	51.14	50.72	12.94	12.53	12.74	63.24	63.67	63.46
T_2- Metribuzin @ 0.250 Kg /ha	51.41	52.68	52.04	13.22	12.88	13.05	64.62	65.56	65.09
T_3-Butachlor @ 1 lit/ha	50.12	49.92	50.02	12.95	12.56	12.75	63.06	62.48	62.77
T_4- Clodinafop-propargyl @ 0.140 kg /ha	51.92	51.29	51.60	13.36	12.90	13.13	65.28	64.18	64.73
T_5 - 2, 4-D @ 0.5 lit/ha *fb* metribuzin @ 0.250 Kg /ha	50.73	50.61	50.67	13.09	12.97	13.03	63.82	63.59	63.70
T_6- 2, 4-D @ 0.5 lit/ha*fb* butachlor @ 1 lit/ha	51.75	50.35	51.05	13.38	12.71	13.05	65.13	63.06	64.09
T_7- Metribuzin @ 0.250 Kg /ha *fb* butachlor @ 1 lit/ha	50.65	51.44	51.05	13.01	12.71	12.86	63.66	64.16	63.91
T_8- 2, 4-D @ 0.5 lit/ha + hand weeding at 30 DAS	50.83	50.56	50.69	13.10	12.27	12.68	63.92	62.83	63.38
T_9- Hand Weeding at 30 DAS	53.21	53.00	53.10	13.72	13.01	13.37	66.93	66.01	66.47
T_{10}- Weedy check	52.63	50.01	51.32	13.63	12.59	13.11	66.26	62.61	64.43
SEm±	0.97	0.80	0.62	0.27	0.26	0.18	1.24	0.98	0.78
CD (P=0.05)	2.84	2.33	1.77	0.79	0.75	0.52	3.62	2.86	2.22

3.3.2 Belowground CO_2 equivalent C stock (t/ha)

The belowground CO_2 equivalent C stock of eucalyptus tree range between 40.94 to 42.66 t/ha and from 49.23 to 52.74 t/hawas found during first and second year of experiment and the pooled mean of two year showed that belowground CO_2 equivalent C stockin eucalyptus tree varied from 45.20 to 46.66 t/ha was found under wheat-*Eucalyptus tereticornis* based agroforestry system(Table 3).

3.3.3 Total CO_2 equivalent C stock by tree (t/ha)

During first year (2016-17) the total CO_2 equivalent C stock of eucalyptus tree range between 195.11 to 204.61 t /haand ranged from 248.39 to 258.78 t/ha was found during second year (2017-18) under wheat-*Eucalyptus tereticornis* based agroforestry system.

The statistical analysis of the pooled data showed that the CO_2 equivalent C stockin eucalyptus tree varied from 224.18 to 230.86 t/ha was found under wheat-*Eucalyptus tereticornis* based agroforestry system (Table 3).

3.4 Carbon Dioxide Equivalent C Stock from Agroforestry System (t/ha)

3.4.1 Aboveground CO_2 equivalent C stock in agroforestry system (t/ha)

The aboveground CO_2 equivalent C stockin agroforestry vegetation was found range between 50.12 to 53.21 t/ha during first year (2016-17) and second year (2017-18) aboveground CO_2 equivalent C stockin agroforestry system ranged from 49.92 to 53.00 t/ha was found. The pooled data showed that the higher aboveground CO_2 equivalent C stockin agroforestry system was found under hand weeding at 30 DAS (53.10 t/ha) over all the weed control treatment due to higher biomass. The aboveground CO_2 equivalent C stockin agroforestry system varied from 50.02 to 53.10 t/ha under wheat-*Eucalyptus tereticornis* based agroforestry system (Table 4).

3.4.2 Belowground CO_2 equivalent C stock (t/ha)

During first year the belowground CO_2 equivalent C stockin agroforestry system range between 12.95 to 13.72 t/ha was found and During second year belowground CO_2 equivalent C stockin ranged from 12.27 to 13.01 t/ha was found under wheat-*Eucalyptus tereticornis* based agroforestry system(Table 4).

The pooled data showed that the average belowground CO_2 equivalent C stock varied from 12.68 to 13.37 t/hawas found under wheat-*Eucalyptus tereticornis* based agroforestry system (Table 4).

3.4.3 Total CO_2 equivalent C stock in agroforestry system (t/ha)

The total CO_2 equivalent C stockin agroforestry system was found higher in hand weeding 30 DAS (66.93 t/haand 66.01 t/haduring both of the year) over rest of the weed control treatment. CO_2 equivalent C stockwas found range between 63.06 to 66.93 t/haand 62.48 to 66.01 t/haduring 2016-17 and 2017-18 under wheat-*Eucalyptus tereticornis* based agroforestry system (Table 4).

The pooled data showed that total CO_2 equivalent C stockin agroforestry system was found varied from 62.77 to 66.47 t/ha under wheat-*Eucalyptus tereticornis* based agroforestry system (Table 4). Thevathasan and Gorden [2] also concluded that, the annual CO_2 equivalent carbon stock in a hybrid poplar intercropping field was four times higher as compared to sole agriculture cropping fields. Higher CO_2 equivalent carbon stock in intercropping system compared to sole cropping system has supported in case of Pauownia+winter wheat [3] and poplar based system [4]. The results of present study was also confirm with the findings Mangalassery et al. [5], Prasad et al. [6], Rijvi et al. [7], Swamy and Mishra [8] and Chauhan et al. [9-12].

4. CONCLUSION

The agroforestry system play vital role to absorb atmospheric carbon dioxide and stored in different component. The agroforestry system was pooled higher carbon dioxide equivalent carbon stock due to higher biomass potential of more than one component such as crop, weed and trees than the solo cropping pattern. Under Agroforestry System we conclude that on average two year the wheat crop have capacity to store 9.68 to 14.85 t/ha, different weed have capacity to store 0.38 to 4.38t/ha with different weed management under the eucalyptus tree. The eucalyptus tree store 225.22 to 231.65 t/ha carbon dioxide equivalent carbon stock. The pooled mean of two year experiment total CO_2

equivalent C stock in agroforestry system was found varied from 62.77 to 66.47 t/ha under wheat-*Eucalyptus tereticornis* based agroforestry system with different weed control treatment.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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